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Emotionality effects in Korean visual word recognition: Evidence from lab-based and web-based lexical decision tasks☆

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ABSTRACT

Previous studies have shown that processes of word recognition are influenced by the emotional content of a word. This pattern is most readily explained by the motivated attention and affective states model (Lang, Bradley & Cuthbert, 1997), which states that emotional stimuli are motivationally significant and capture attention. Drawing on this theoretical account, the current study compared lexical decision response times to positive and negative emotion words versus neutral words across two experimental environments - a traditional lab-based environment and a web-based environment. In addition, the experiment was conducted using Korean words presented to native Korean speakers in order to test whether the emotionality effect emerges in a non-English language. The results revealed faster response times to emotion words versus neutral words across both experimental environments with no evidence of a difference between the two environments. These findings provide important evidence that emotion words successfully attract attention and facilitate word processing even in situations where participants might be more easily distracted than they would be in a traditional lab setting. This work also constitutes the first demonstration of an emotionality effect in Korean word recognition, thus providing further evidence that the emotionality effect may be a language-universal phenomenon.

1. Introduction

Emotions play a crucial role in allowing us to perceive, categorize, and ultimately respond appropriately to potentially threatening stimuli. This ability extends into modern life, where we must often perceive subtle cues in social events and interpersonal relationships (Dolan, 2002). This ability is especially well-adapted to perceiving the emotions in facial expressions. For example, people can recognize emotional facial expressions faster than neutral facial expressions (see Schindler & Bublatzky, 2020 for a review). Rapid and preferential responses to these emotional stimuli are thought to be biologically adaptive, and the ability to assess people's emotions from their facial expressions facilitates social interactions.

Meanwhile, as a "symbolic species", humans can use language, a highly abstract signaling system, to efficiently communicate information about themselves and their surroundings. Therefore, it is essential that we be able to recognize emotions in language, which is one of the most important characteristics of a literate society. Investigations of how people respond to emotional words can be classified into two broad categories: the processing of words that name emotions (e.g., gratitude, anger) and the processing of emotion-laden words—that is, words that do not refer to an emotion but can provoke emotional states (e.g., party, cancer). According to dimensional theories of emotion, emotional words (both those that name emotions as well as emotion-laden words) can typically be characterized according to their level of arousal (high versus low), as well as their valence (positive versus negative) (Russell, 1991). A considerable number of studies have been conducted over the past several decades regarding the processes involved in the recognition of emotional words; by and large, these studies have shown that emotional words are processed differently from neutral words (Citron, 2012). Table 1 summarizes a few recent studies on the role of emotion in word recognition.

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As shown in Table 1, there are substantial differences in the processing patterns between emotional and neutral words across a range of methodologies. Upon careful inspection of the results, however, interesting patterns emerge. For example, several studies have shown that negative words are processed slower than neutral words (e.g., Algom, Chajut, & Lev, 2004; Estes & Adelman, 2008; Kuperman, Estes, Brysbaert, & Warriner, 2014; Wentura, Rothermund, & Bak, 2000). In addition, some early studies using emotional Stroop-type tasks have demonstrated that negative words elicit slower responses compared to positive or neutral words (for a review, see Williams, Mathews, & MacLeod, 1996). More recently, Kuperman et al. (2014) conducted a series of regression analyses with confounding variables well controlled and observed that longer response latencies were associated with more negative emotionality in a lexical decision task and a naming task (see also Estes & Adelman, 2008). Additional work by Kuperman (2015) showed similar patterns across several megastudies using a bootstrapping technique. Findings such as these are often explained under the automatic vigilance hypothesis, which posits that emotionally negative words capture attention more strongly than other words.

Although the studies discussed above have reported a processing delay for negative words, many other studies have demonstrated processing advantages for emotional words relative to neutral words irrespective of valence. For example, Scott, O'Donnell, and Sereno (2014) observed faster reaction times in a lexical decision task (LDT) for emotional words compared to neutral words (see also Kanske & Kotz, 2007; Kissler, Herbert, Winkler, & Junghofer, 2009; Kousta, Vinson, & Vigliocco, 2009; Schacht & Sommer, 2009; Scott et al., 2014; Scott, O'Donnell, Leuthold, & Sereno, 2009; Vinson, Ponari, & Vigliocco, 2014). Further, positive words showed shorter response latencies compared to neutral words. However, Scott et al. also reported that the response times to negative emotion words were facilitated only for low frequency words, indicating that word frequency plays an important role in the recognition of negative words. Finally, in a recent study, Gao, Shinkareva, and Peelen (2022) showed that response times in an auditory LDT were facilitated for words with both negative and positive valence relative to neutral words. In contrast, response times in a visual LDT in the same study showed facilitation only for words with positive valence. Taken together, these results suggest that the effect of valence on word recognition may differ depending on the modality of the presented word.

The advantage for processing emotional words has also emerged in other paradigms in which a target word (i.e., emotional or neutral) is embedded in fully structured grammatical sentences. For example, Knickerbocker, Johnson, and Altarriba (2014) recorded readers' eye movements during reading and compared fixation durations on emotional versus neutral target words. The results showed shorter fixation durations on emotional words versus neutral words (see also Scott, O'Donnell, & Sereno, 2012; Sheikh & Titone, 2013; Yan & Sommer, 2018). Furthermore, Knickerbocker and Altarriba (2013), using the RSVP paradigm, reported a significantly larger repetition blindness effect for emotional words than for neutral words, demonstrating that participants had difficulty noticing a target word when it was repeated in the same trial as compared to when it was not repeated, and that this difficulty was even stronger when the word was emotional than neutral (see also Silvert, Naveteur, Honore, Sequeira, & Boucart, 2004). This pattern indicates that emotional words tend to receive greater attention than neutral words during visual word recognition (see also Wentura, Müller, & Rothermund, 2014 for a similar pattern of results with a visual search task).

There are a few theoretical accounts that explain the processing advantage of emotional words. First, the emotionality effect can be explained from an evolutionary perspective that posits two motivational systems—an approach-appetitive system and a withdrawal-aversive system (Bradley, 2000). According to this explanation, negative

Table 1
Examples of studies published on emotional word recognition since 2010.

Authors	Year	Word types	Language	Method	Main results
Altarriba & Basnight-Brown	2010	Emotion, emotion-laden X positive, negative	English	- Affective Simon Task	- Negative and positive emotion-laden words produced Simon effects
Gao, Shinkareva & Peelen	2022	Considered valence as continuous variable X visual LDT, auditory LDT	English	- LDT	- RT: positive < neutral for visual LDT - RT: positive, negative < neutral for auditory LDT
Kazanas & Alttariba	2015	Emotion, emotion-laden X positive, negative	English	- Priming	- RT: emotion words < emotion-laden words - RT: positive words < negative words - Priming effects: emotion words > emotion-laden words - Priming effects: positive words > negative words
Knickerbocker & Altarriba	2013	Emotion, emotion-laden, neutral	English	- Rapid serial visual presentation	- RB effect: emotion > emotion-laden, neutral
Knickerbocker, Johnson, & Altarriba	2014	Positive, negative, neutral	English	- Eye tracking	- Fixation duration: positive, negative < neutral
Kuperman, Estes, Brysbaert & Warriner	2014	Positive, negative, neutral X HF, LF	English	- LDT - Naming	- RT: negative > neutral - RT: positive < neutral - RT: arousing words > calming words - Valence and arousal exert larger effect among LF words vs. HF words
Scott, O'Donnell & Sereno	2012	Positive, negative, neutral X HF, LF	English	- Eye tracking	- Fixation duration: LF positive, negative < neutral - Fixation duration: HF positive < negative, neutral
Scott, O'Donnell & Sereno	2014	Positive, negative, neutral X HF, LF	English	- LDT	- RT: positive < neutral words - RT: negative < neutral words for LF words
Vinson, Ponari & Vigliocco	2014	Considered valence as continuous or discrete variable (negative/positive, valenced/neutral)	English	- LDT	- RT: positive, negative < neutral words
Yan & Sommer	2018	Positive, negative, neutral X Parafoveal identical, masked	Chinese	- Eye tracking - Boundary paradigm	- Fixation duration: negative < neutral - Negative foveal words can diminish parafoveal processing

RT = reaction time; RB = repetition blindness; LDT = lexical decision task; HF = high frequency; LF = low frequency.

emotions must be processed rapidly, because rapid withdrawal from potentially life-threatening situations is an evolutionarily adaptive behavior. Furthermore, the withdrawal-aversive system takes precedence over the approach-appetitive system, as the rapid escape from a negative stimulus is more conducive to survival than the rapid approach toward a positive stimulus. Thus, this framework can explain the phenomenon that stimuli with negative valence are processed faster than stimuli with positive valence as well as emotionally neutral ones (Knickerbocker et al., 2014; Pratto & John, 1991). However, as mentioned above, many studies have reported a processing advantage for stimuli with positive valence relative to stimuli with neutral valence, and this explanation does not sufficiently explain these results. In addition, this explanation is limited in that it cannot explain the inhibitory effect of negative emotions on word processing.

A different explanatory framework argues that the processing advantages for emotional stimuli, regardless of valence, can be accounted for through motivated attention and affective states models (Lang, Bradley, & Cuthbert, 1997). According to this account, emotional stimuli maintain a processing advantage over neutral stimuli because they are motivationally significant and can capture attention earlier than neutral stimuli. This focused attention can then enable a deeper level of processing of the stimuli, allowing semantic information such as emotionality to play a greater role in task performance. This explanation is supported by the results of large-scale regression analyses, which have demonstrated that lexical decisions to both negative and positive words are faster and more accurate than those to neutral words, even after controlling for a variety of lexical and semantic features (Kousta et al., 2009; Vinson et al., 2014).

1.1. Web-based experimental procedures

For a variety of reasons, the past decade has seen a huge increase in the number of behavioral experiments that are conducted on web-based platforms (e.g., Chetverikov & Upravitelev, 2015; Crump, McDonnell, & Gureckis, 2013; de Leeuw & Motz, 2015; Germine et al., 2012; Hilbig, 2016; Kim, Lowder, & Choi, 2021; Kochari, 2019; Miller, Schmidt, Kirschbaum, & Enge, 2018; Simcox & Fiez, 2013). Not only do web-based experiments allow researchers to collect data in a faster and more economical way (Kochari, 2019), but this approach has become mandatory for many researchers as the COVID-19 pandemic has made face-to-face data collection more difficult or in some cases impossible.

Recent studies have demonstrated that valid and reliable data can be obtained from web-based experiments. For example, the performance of online participants in instructional manipulation checks (i.e., questions designed to assess how attentive participants are to instructions; Oppenheimer, Meyvis, & Davidenko, 2009) was not different from that of supervised participants (Goodman, Cryder, & Cheema, 2013). In addition, many well-established effects obtained using lab-based experimental procedures on topics such as attention, executive control, word recognition, and sentence processing have been successfully replicated via web-based studies (e.g., Barnhoorn, Haasnoot, Bocanegra, & van Steenbergen, 2015; Hilbig, 2016; Kim, Baek, Lee, & Choi, 2021; Kim, Lowder and Choi, 2021; Semmelmann & Weigelt, 2017). Therefore, although the lack of experimenter supervision in web-based experiments may raise skepticism among some, studies that have directly compared results across lab-based and web-based experiments strongly suggest that web-based data collection is a reliable methodological approach.

One difference that has been documented is that participants in web-based experiments tend to show slower response latencies than those in lab-based experiments. For example, using a web-based LDT, Kim, Lowder, et al. (2021) successfully replicated the results reported in Lee, Seong, Choi, & Lowder, 2019, which was conducted in a lab-based procedure. However, interestingly, Kim et al. reported overall response times approximately 100 ms slower than the response times reported in Lee et al. Similar results were reported by Hilbig (2016), who examined the word frequency effect in LDT across three different experimental environments: laboratory environment using standard experimental software, laboratory environment using a browser-based experiment, and web-based environment using the browser-based experiment. The results showed that although the frequency effect was comparable across the three environments, the overall reaction time was the shortest in the laboratory environment in which standard experimental software was used, while the longest reaction time was in the web-based environment. These results suggest that participants' level of attention may be lower in web-based environments compared to lab-based environments.

Others have raised similar concerns regarding lower levels of attention in web-based versus lab-based experiments (Woods, Velasco, Levitan, Wan, & Spence, 2015). For example, Chandler, Mueller, and Paolacci (2014) conducted a survey to determine whether online participants recruited through Mechanical Turk were fully focused while participating in the study. The authors asked 300 participants what they did while participating in web-based studies. The results showed that 18 % of respondents reported watching TV. Additionally, 14 % said they listen to music, and 6 % said they communicate with others online.

According to the motivated attention and affective states models, emotional stimuli are processed faster than emotionally neutral stimuli because they easily capture attention. Therefore, in a web-based experimental environment where participants' overall attention is likely to be lower than that of participants in a lab-based environment, it is reasonable to predict that the emotionality effect may also differ across the two environments; however, the precise nature of this difference is unclear. There are several possible hypotheses: (1) If the attention levels among participants in the two environments are generally the same, then the processing advantage for emotional stimuli versus neutral stimuli should also be similar. However, (2) if the attention levels among participants in a web-based environment are lower than that of participants in a lab-based environment, then it is possible that (2a) emotional stimuli in the web-based experiment will not attract attention, resulting in an emotionality effect that is either reduced or eliminated. On the other hand, (2b) emotional stimuli in a web-based experiment may exert an even greater "pop-out" effect on attention, resulting in an emotionality effect that is larger than in a lab-based experiment. These possibilities were tested in the current study by conducting an LDT using emotion word stimuli that was administered in lab-based and web-based experimental environments.

1.2. Emotion recognition in different cultures and directions of the current study

An additional question is whether the processing benefit of emotional words emerges across languages and cultures. With respect to emotional word recognition, most studies to date have been conducted in alphabetic languages, although a few have been conducted in logographic languages like Chinese (Wang, Shangguan, & Lu, 2019; Yan & Sommer, 2018; Zhang, Wu, Meng, & Yuan, 2017). For example, Yan and Sommer (2015) conducted an eyetracking-while-reading experiment on the processing of emotional words embedded in Chinese sentences. Results showed shorter fixation durations for emotional words compared to neutral words. However, there is still a severe lack of research on the effects of emotion in lexical processing in non-alphabetic languages other than Chinese, such as Korean. Further, several studies have reported that perception of emotion may vary depending on culture (for a review, see Russell, 1994); thus, it seems possible that the processing of emotional words may also vary depending on language or culture. In particular, Russell and Sato (1995) compared native speakers of English, Chinese, and Japanese on their ratings of how well emotion words were matched to corresponding facial expressions. Results showed generally high agreement across cultures; however, there were also cross-cultural differences for certain faces like excited and disgusted. Regarding the recognition of emotional words, Rodriguez-

Ferreiro and Davies (2019) examined the effect of word valence and arousal using a word naming task and an LDT in Spanish. In contrast to English, Spanish is an example of a language with a very consistent relationship between spelling and pronunciation. This feature of the language might be associated with more rapid lexical encoding, in which case semantic information such as valence and arousal might exert a weaker effect on the processes of word recognition. Nevertheless, Rodriguez-Ferreiro and Davies showed a valence effect in the processing of Spanish words, indicating that the emotional content of words affects lexical processing in an orthographically transparent language in addition to a less transparent language like English.

An important goal of the current study was to examine further the cross-cultural and cross-linguistic nature of the emotionality effect in word recognition. To this end, we tested samples of native Korean speaking participants using Korean words. This is important because to our knowledge, there have been no previous studies on emotional word processing in Korean. In addition, the inclusion of Korean speakers in the current study advances the goal of investigating the processing of emotional stimuli across languages and cultures.

In summary, the goals of the present study were twofold. First, we examined whether the emotionality effect on word recognition in LDT differs across lab-based and web-based experimental environments. Second, we examined the processing of emotional words in Korean among native Korean speaking participants. In Experiment 1, participants visited the laboratory and performed the LDT on emotional and neutral words that were well-matched on a variety of lexical characteristics. In Experiment 2, participants performed the same task using the same stimuli in a web-based environment.

2. Experiment 1

2.1. Experiment 1a

2.1.1. Method

2.1.1.1. Participants. Forty undergraduate and graduate students in their 20s (21 females) from Gwangju Institute of Science and Technology took part in the experiment. All participants were native speakers of Korean.

2.1.1.2. Stimuli. Twenty-four words referring to positive emotions (e.g., 애정(love)), 24 neutral words (e.g., 신호(signal)), and 48 nonword stimuli were used. The emotion words were selected among the stimuli used in Kwon (2018). The full set of words is presented in Appendix 1a. All positive words in the list referred to specific states of emotion (i.e., they did not merely have positive emotional connotations). Word frequency and syllabic neighborhood size were computed based on the Korean National Corpus of the 21st Sejong Project (National Institute of Korean Language, 2020). As seen in Table 2, the positive and neutral words did not differ in syllable length, word frequency, or number of syllable neighbors ($ts < 1$, $p > .05$). To test for possible differences in concreteness, 24 participants who did not perform the LDT were recruited to evaluate concreteness on a 7-point Likert scale (1 = most abstract, 7 = most concrete). Results showed that neutral words were rated as significantly more concrete than positive words ($t(46) = -7.35$, $p < .0001$). Given that concreteness is one of the key variables affecting word recognition, especially in relation to emotionality (Kanske & Kotz, 2007), the concreteness ratings were included in the statistical models (discussed below).

To ensure that the two word conditions differed in emotional arousal and valence, a group of 37 participants who did not participate either in the LDT or in the concreteness norming study were recruited to evaluate the arousal and valence of words on a 7-point Likert scale (arousal: 1 = least arousing, 7 = most arousing; valence: 1 = most negative, 7 = most positive). The emotion words were rated as significantly more positive than the neutral words ($t(46) = -19.51$, $p < .001$). In addition, the emotion words were rated as significantly higher in arousal than the neutral words ($t(46) = 3.78$, $p < .001$).

2.1.1.3. Apparatus. The experiment was presented using *E*-Prime3.0 software. The screen resolution was 1920 × 1080 pixels. Stimuli were presented in 80-point Consolas font.

2.1.1.4. Procedure. After providing informed consent, participants were given instructions on how to complete the LDT. Each trial began with a fixation cross in the center of the screen for 1000 ms. Then, the stimulus was presented and remained on the screen until the participant responded. An initial warmup block of 20 stimuli was presented to get participants used to performing the task. After this warmup block, the 96 experimental stimuli were presented randomly.

Participants responded using a wired response pad (Cedrus RB-740 response pad). They were instructed to press the left blue button if they judged that the stimulus was a word, and the right red button if they judged that the stimulus was not a word. Participants were encouraged to respond as quickly and as accurately as possible. Each experimental session lasted approximately 10 min.

2.1.1.5. Analysis. Excessively short or long reaction times (i.e., trials outside the range of $M \pm 2.5$ SD for each participant) were excluded from the analysis under the assumption that these do not reflect cognitive processes involved in word recognition. Incorrect responses were also excluded from the response time analyses. In total, data from 1820 trials out of the full dataset of 1920 trials were used for analysis.

Data were analyzed using linear mixed-effects models with participants and items entered as crossed random effects. Analyses were conducted using the lmer function of the lme4 package (Bates, Maechler, Bolker, & Walker, 2015) in R (R Core Team, 2019). All *p*-values were obtained using the lmerTest package (Kuznetsova, Brockhoff, & Christensen, 2017). Fixed effects included the emotionality of the word (i.e., positive or neutral) and the concreteness ratings. The random effects structure initially included by-subject and by-item random intercepts as well as by-subject random slopes for the emotionality condition. Because this model failed to converge, the random effects structure was simplified until the model fit reached convergence. The final models included by-subject and by-item random intercepts, but not random slopes.

2.1.2. Results

Overall response accuracies were high ($M = 0.96$, $SD = 0.21$) and did not differ across the emotionality conditions ($ts < 1$). Table 3 shows the means and standard deviations of response times and accuracies for each condition.

As shown in Table 4, the emotionality effect was statistically significant, indicating that RTs for positive words were significantly faster than those for neutral words. The effect of concreteness was not significant. The RT results clearly show that words with positive emotionality are processed faster than those with neutral emotionality, even when the concreteness of the words was statistically controlled.[4]

2.2. Experiment 1b

2.2.1. Method

2.2.1.1. Participants. Forty undergraduate and graduate students in

[4] As noted by an anonymous reviewer, it is possible that the RT difference between positive and neutral words could be driven by differences in arousal rather than valence. To address this concern, we ran a supplemental analysis that included the fixed effect of arousal as a continuous variable in the model. Results showed that the emotionality effect was still statistically significant in a model that included arousal ($b = -49.75$, $SE = 20.18$, $t = -2.47$, $p < .05$).

Table 2
Emotional and linguistic characteristics of the words (Neutral/Positive).

Condition	Arousal	Valence	Syllable length	Frequency (per million)	Number of syllabic neighbors	Concreteness
Neutral	3.75 (0.30)	4.08 (0.31)	2.17 (0.38)	350 (295)	684 (550)	5.1 (1.83)
Positive	4.65 (1.12)	6.03 (0.38)	2.13 (0.34)	351 (292)	725 (812)	3.44 (1.69)

Note. The mean value for each condition is reported, and the standard deviation is reported in parentheses.

Table 3
Experiment 1a reaction times and accuracies per condition. (standard deviations in parentheses, $N = 40$).

	Neutral	Positive
RT (milliseconds)	556 (140)	522 (140)
Accuracy	0.97 (0.18)	0.99 (0.12)

Note. RT = reaction time.

Table 4
Summary of linear mixed-effects model analysis of Experiment 1a. ($N = 40$).

	Response times		
	b	*SE*	*t*
(Intercept)	610.12	48.11	12.68***
Emotionality	−47.36	19.56	−2.42*
Concreteness	−9.85	8.95	−1.10

Random effects		*Var*	*SD*
Subject	(Intercept)	5407	73.53
Item	(Intercept)	1914	43.74
Residual		12,764	112.98

Note. *SE* = standard error; *Var* = variance; *SD* = standard deviation.
* $p < .05$.
*** $p < .001$.

their 20s (12 females) from Gwangju Institute of Science and Technology took part in the experiment. They were naïve to the purpose of the experiment and did not participate Experiment 1a. All participants were native speakers of Korean.

2.2.1.2. Stimuli. Twenty-four words referring to negative emotions (e.g., 분노anger), 24 neutral words (e.g., 각색(adaptation)), and 48 nonword stimuli were selected from Kwon (2018). As seen in Table 5, the negative and neutral words did not differ in syllable length, word frequency, or number of syllable neighbors ($ts < 1$, $p > .05$). To test for possible differences in concreteness, the same 24 participants who participated in the concreteness norming study in Experiment 1a evaluated concreteness on a 7-point Likert scale (1 = most abstract, 7 = most concrete). Results showed that neutral words were rated as significantly more concrete than negative words ($t(46) = -8.07$, $p < .0001$).

To ensure that the two word conditions differed in emotional arousal and valence, the same 37 participants who participated in the emotionality norming study in Experiment 1a evaluated the arousal and valence of words on a 7-point Likert scale (arousal: 1 = least arousing, 7 = most arousing; valence 1 = most negative, 7 = most positive). The emotion words were rated as significantly more negative than the neutral words ($t(46) = -18.79$, $p < .001$). In addition, the emotion words were rated as significantly higher in arousal than the neutral words ($t(46) = 4.84$, $p < .001$).

2.2.1.3. Apparatus. All aspects of the experimental software, screen resolution, and font were identical to that described in Experiment 1a.

2.2.1.4. Procedure. The procedure was identical to the procedure described in Experiment 1a.

2.2.1.5. Analysis. Four participants with accuracy rates <75 % were removed. Thus, the analyses reported below were conducted on 36 participants. Excessively short and long trials were excluded based on the same criteria as in Experiment 1a. In total, data from 1620 trials out of the full dataset of 1728 trials were used for analysis. Statistical analyses were conducted using the same procedures described in Experiment 1a except that the two levels of word emotionality were negative versus neutral.

2.2.2. Results

Overall response accuracies were high ($M = 0.95$, $SD = 0.21$) and did not differ across the emotionality conditions ($ts < 1$). Table 6 shows the means and standard deviations of response times and accuracies for each condition.

As shown in Table 7, the emotionality effect was statistically significant, indicating that RTs for negative words were significantly faster than those for neutral words. The effect of concreteness was not significant. Similar to Experiment 1a, the RT results of the current experiment clearly show that the words with negative emotionality are processed faster than those with neutral emotionality, even when the concreteness of the words was statistically controlled.[5]

2.3. Discussion of Experiment 1a and 1b

The results from Experiment 1a and 1b are straightforward. Compared to neutral words, participants were faster to recognize both positive and negative emotional words. This pattern of results suggests a processing advantage for emotionality during word recognition irrespective of emotional valence.

The results are consistent with the findings reported in several previous studies (Kanske & Kotz, 2007; Kissler et al., 2009; Kousta et al., 2009; Schacht & Sommer, 2009; Scott et al., 2009; Scott et al., 2014; Vinson et al., 2014) showing an advantage for emotional words relative to neutral words during lexical processing. Under the framework of motivated attention, these results are best explained in terms of attention capture such that emotional words are more effective at capturing attention, which then leads to more efficient processing.

The current results also demonstrate that the emotionality effect of word processing can emerge in Korean. This is important, given that the vast majority of previous studies on this effect have been conducted in alphabetic languages like English.

3. Experiment 2

3.1. Method

3.1.1. Participants

Fifty-nine college students in their 20s from Yeongnam University in South Korea took part in the experiment. All participants were native speakers of Korean. Participants were recruited through advertisements posted on an online bulletin board at Yeongnam University.

[5] The emotionality effect was marginally significant in a supplemental analysis that included the fixed effect of arousal ($b = -34.68$, $SE = 17.30$, $t = -2.00$, $p = .052$).

Table 5
Emotional and linguistic characteristics of the words (Neutral/Negative).

Condition	Arousal	Valence	Syllable length	Frequency (per million)	Number of syllabic neighbors	Concreteness
Neutral	3.70 (0.36)	4.08 (0.18)	2.13 (0.34)	426 (335)	766 (512)	5.22 (1.68)
Negative	4.99 (1.35)	1.75 (0.19)	2.08 (0.28)	425 (346)	764 (438)	3.57 (1.71)

Note. The mean value for each condition is reported, and the standard deviation is reported in parentheses.

Table 6
Experiment 1b reaction times and accuracies per condition. (standard deviations in parentheses, $N = 36$).

	Neutral	Negative
RT (milliseconds)	514 (123)	493 (109)
Accuracy	0.95 (0.21)	0.98 (0.13)

Note. RT = reaction time.

Table 7
Summary of linear mixed-effects model analysis of Experiment 1b ($N = 36$).

	Response Times		
	B	*SE*	*t*
(Intercept)	550.42	43.96	12.52***
Emotionality	−34.58	17.10	−2.02*
Concreteness	−6.30	8.03	0.44

Random effects		*Var*	*SD*
Subject	(Intercept)	4262	65.29
Item	(Intercept)	1164	34.11
Residual		8266	90.92

NOTE — *SE* = Standard Error; *Var* = Variance; *SD* = Standard Deviation.
* $p < .05$.
*** $p < .001$.

3.1.2. Stimuli

The same words and nonwords that were used in Experiment 1were used in the current experiment. The full set of 24 positive words, 24 negative words, 48 neutral words, and 96 nonwords were presented in one experimental list.

3.1.3. Apparatus

PsychoPy3 and the Pavlovia platform were used to conduct the web-based experiment. PsychoPy3 was used to create the LDT, and the task was then transformed to a JavaScript based format. The Pavlovia platform was used to upload the web-based experiment file and to make it available to participants. In the web-based LDT, each stimulus was presented in NanumGothic font, and the character height ratio of the stimulus/window was 0.1.

3.1.4. Procedure

After providing informed consent, participants received a URL that directed them to the web-based LDT. The experiment consisted of two blocks: one block contained the same positive and neutral words that were used in Experiment 1a, and the other contained the same negative and neutral words that were used in Experiment 1b. The order in which the two blocks were presented was randomly determined. Participants were instructed to determine as quickly and accurately as possible whether each letter string presented on the screen was a real word or not. As in Experiment 1, each trial began with a fixation cross in the center of the screen for 1000 ms. Then, the stimulus was presented and remained on the screen until the participant responded. The same warmup block of 20 stimuli that were used in Experiment 1 was used in the current experiment before presentation of the two experimental blocks. Stimuli were presented randomly. Participants were instructed to press the ‘a’ key if they judged that the stimulus was a word, and the ‘l’ key if they judged that the stimulus was not a word. Each experimental session lasted approximately 20 min.

3.1.5. Analysis

Excessively short and long trials were excluded based on the same criteria as in Experiment 1. For the positive/neutral block of the experiment, data from 2747 trials out of 2832 trials were used for analysis. For the negative/neutral block of the experiment, data from 2698 trials out of 2832 trials were used for analysis. Statistical analyses were conducted using the same procedures described in Experiment 1.

3.2. Results

Overall response accuracies were high ($M = 0.95$, $SD = 0.23$) and did not differ across the emotionality conditions ($ts < 1$). Table 8 shows the means and standard deviations of response times and accuracies for neutral and positive conditions.

Results for the analysis of positive versus neutral words are presented in Table 9. As shown in the table, the emotionality effect was statistically significant, indicating that RTs for positive words were significantly faster than those for neutral words. This pattern is consistent with the results of Experiment 1a.[6]

Table 10 shows the means and standard deviations of response times and accuracies for neutral and negative conditions, and results for the analysis of negative versus neutral words are presented in Table 11. As shown in the table, the emotionality effect was statistically significant, indicating that RTs for negative words were significantly faster than those for neutral words. This pattern is consistent with the results of Experiment 1b.[7]

3.3. Comparison between Experiment 1 and 2

Comparing the results of Experiments 1 and 2, the same conclusions can be drawn regardless of whether the data were obtained through a lab-based or web-based experimental procedure. That is, both experimental environments showed strong evidence for an emotionality effect such that LDT response times for emotional words were significantly shorter than RTs for neutral words. This pattern provides strong evidence that word recognition is facilitated by emotional features of

Table 8
Experiment 2 reaction times and accuracies for the neutral and positive conditions (standard deviations in parentheses, $N = 59$).

	Neutral	Positive
RT (milliseconds)	661 (214)	612 (188)
Accuracy	0.97 (0.16)	0.98 (0.15)

Note. RT = reaction time.

[6] The emotionality effect was still significant in a supplemental analysis that included the fixed effect of arousal ($b = -55.85$, $SE = 25.10$, $t = -2.23$, $p < .05$).

[7] The emotionality effect was still significant in a supplemental analysis that included the fixed effect of arousal ($b = -47.35$, $SE = 21.29$, $t = -2.22$, $p < .05$).

Table 9
Summary of linear mixed-effects model analysis of the neutral versus the positive conditions ($N = 59$).

	Response Time		
	B	*SE*	*t*
(Intercept)	703.79	59.99	11.73***
Emotionality	−61.62	25.36	−2.43*
Concreteness	−8.25	11.29	−0.73

Random effects		*Var*	*SD*
Subject	(Intercept)	8059	89.77
Item	(Intercept)	3078	55.48
Residual		29,495	171.74

Note. *SE* = standard error; *Var* = variance; *SD* = standard deviation.
* $p < .05$.
*** $p < .001$.

Table 10
Experiment 2 reaction times and accuracies for the neutral and negative conditions (standard deviations in parentheses, $N = 59$).

	Neutral	Negative
RT (milliseconds)	624 (217)	594 (239)
Accuracy	0.96 (0.16)	0.99 (0.11)

Note. RT = reaction time.

Table 11
Summary of linear mixed-effects model analysis of the neutral versus the negative conditions ($N = 59$).

	Response Time		
	b	*SE*	*t*
(Intercept)	675.16	53.85	12.54***
Emotionality	−47.31	21.04	−2.25*
Concreteness	−9.37	9.86	−0.95

Random effects		*Var*	*SD*
Subject	(Intercept)	9424	97.08
Item	(Intercept)	1388	37.25
Residual		41,914	204.73

NOTE — *SE* = Standard Error; *Var* = Variance; *SD* = Standard Deviation.
* $p < .05$.
*** $p < .001$.

words.

Table 12 presents the effect sizes of Experiment 1 and Experiment 2. As shown in the table, moderate-to-strong effect sizes emerged in both experiments. In both experiments, the effect sizes of the positive words relative to neutral words were generally larger than the effect sizes of the negative words relative to neutral words. Also, effect sizes were slightly larger in Experiment 1 versus Experiment 2; however, the difference was minimal. The overall pattern indicates that the processing of emotional words is facilitated relative to neutral words, regardless of whether stimuli are presented in a web-based or lab-based environment. This suggests that there were no major differences in participants' attention levels between the two experimental environments.[8]

Table 12
Comparison of effect sizes between Experiment 1 and Experiment 2.

	Condition	Cohen's *d*	Effect-size *r*
Experiment 1 (Lab-based)	Neutral vs. Positive	0.91	0.41
	Neutral vs. Negative	0.64	0.31
Experiment 2 (Web-based)	Neutral vs. Positive	0.83	0.38
	Neutral vs. Negative	0.57	0.27

4. General discussion

Experiment 1 demonstrated in a traditional lab-based environment that reaction times to both positive and negative Korean emotional words are faster than reaction times to neutral words. This pattern indicates that emotional words are recognized faster than neutral words, thus supporting the idea that emotion is a key factor involved in lexical access. These results replicate and extend the results reported in previous studies (e.g., Kousta et al., 2009; Yap & Seow, 2014), which have demonstrated an emotionality effect in the processing of English words. Our demonstration of an emotionality effect in the processing of Korean words provides evidence that the role of emotion in word recognition occurs irrespective of language.

Experiment 2 replicated the results of Experiment 1 using a web-based experimental environment. Cross-experiment comparison of the effect sizes between the lab-based and web-based tasks revealed minimal differences. This pattern argues against the possibility that participants in web-based experiments devote less attention to the task compared to participants in lab-based experiments.

The processing advantage for emotional words is easily explained through the motivated attention account (Lang, Bradley, & Cuthbert, 1990). The motivated attention account proposes that stimuli high in emotional arousal can facilitate the processing of those stimuli regardless of whether the stimulus has a positive or negative valence. That is, more attention is directed toward emotional stimuli, which promotes a deeper level of processing, thus allowing semantic information such as emotionality to play a greater role in task performance. Applying this framework to the current study, the faster reaction times to emotional words versus neutral words is due to enhanced recruitment of attention toward the emotional words, which in turn facilitates lexical processing.

The results of the current study, along with many others, suggest that there is a quadratic relationship between emotionality and reaction times, such that reaction times for both negative and positive words are faster than reaction times for neutral words. In contrast, other studies have reported a linear relationship between emotionality and reaction times such that reaction times to negative words are slower than neutral words, whereas positive words are faster than neutral words (e.g., Kuperman, 2015; Kuperman et al., 2014). There are a number of possible reasons for this discrepancy in findings. As Kuperman pointed out, the quadratic relationship observed in previous studies could be due to experimenter bias in item selection or inadequate statistical power. One interesting possibility with regard to the inconsistent results is that the effect of emotionality could be task specific. According to Estes and Verges (2008), the slowed response for the negative words disappeared when a task was valence-relevant. Although there has been a great deal of research on the effect of emotionality on word recognition, we note that future research should consider factors that may affect the relationship between the two, such as the nature of the task.

Although word frequency was carefully controlled in the current study, previous work has suggested that word frequency can modulate the emotionality effect during word processing. For example, Scott et al. (2009) found that lexical decision times for low frequency emotional words were faster than neutral words regardless of valence, while lexical decision times for high frequency emotional words were faster than neutral words only for the positive words (see also Scott et al., 2014). In

[8] Additional support for this argument comes from an additional statistical analysis in which we tested for an interaction between the emotionality effect and the experimental setting condition. There was no evidence for an interaction when comparing the positive versus neutral conditions ($b = -11.34$, $SE = 9.15$, $t = -1.24$, $p = .22$), nor the negative versus neutral conditions ($b = -8.47$, $SE = 10.77$, $t = -0.79$, $p = .43$).

addition, Scott et al. (2012) have reported effects of word frequency on the processing of negative emotional words during natural sentence reading. Because these previous studies have been conducted in English, further research is needed to determine whether this modulating effect of word frequency on the processing of emotional words emerges in other languages and experimental paradigms.

As described above, the vast majority of studies investigating the effects of emotionality on word recognition have been conducted in English. To the best of our knowledge, studies on the processing of emotional words in non-English languages have mainly been conducted in Chinese (Wang et al., 2019; Yan & Sommer, 2015; Yan & Sommer, 2018; Zhang et al., 2017). For example, Yan and Sommer (2018) investigated whether foveal and parafoveal lexical processing were affected by foveal emotional words when reading Chinese sentences. They found that when the preview duration was increased, the parafoveal preview effect of negative words was smaller than that of neutral words and positive words. Thus, although some studies on the emotionality effect in non-English languages, including the current one, provide evidence for a processing advantage for emotional words, other studies provide evidence that negative words are processed differently than positive words. Although these discrepant findings may be explained by differences in experimental paradigms, further research is needed before such a conclusion can be reached.

Although this experiment provides strong evidence for an emotionality effect in Korean, future work is needed to address shortcomings of this study. For example, the design of Experiment 1 tested one sample of participants on positive versus neutral words (Experiment 1a) and a different sample of participants on negative versus neutral words (Experiment 1b). Participants in Experiment 2 saw positive, negative, and neutral words; however, the stimuli were presented in separate blocks for positive versus negative. We acknowledge this design choice as one limitation of our experiment. One potential avenue for future research would be to randomly present positive, negative, and neutral words to the same sample of participants to provide a more direct test of the emotionality effect within the same participants.

An important contribution of this work is our demonstration of an emotionality effect on word recognition in a web-based experimental environment, which is far less controlled than traditional laboratory-based environments. This suggests that even in an experimental environment where participants can more easily be distracted, emotional words still successfully attracted attention and facilitated word recognition. Notably, we found that the overall response time was slightly longer in the web-based environment. That is, the average response time in the laboratory-based LDT experiment was 523 ms, while the average response time in the web-based LDT experiment was 622 ms, showing a delay of about 100 ms. This difference may be due to several factors, such as imprecise recording of response times over the web or distraction in an unsupervised environment, which are frequent concerns about web-based experiments (Woods et al., 2015). Crucially though, considering the fact that web-based environments do not tend to affect the magnitude of the difference between experimental conditions (De Leeuw & Motz, 2016; Hilbig, 2016; Kochari, 2019; Reimers & Stewart, 2015; Semmelmann & Weigelt, 2017), we believe it is reasonable to conclude that results obtained through web-based experimental procedures are valid and reliable. Supporting this conclusion, the current study showed a minimal difference in effect sizes between lab-based and web-based environments. In sum, the current study adds to the literature showing successful replications of the results of lab-based experiments in web-based environments (Hilbig, 2016; Kim, Baek, et al., 2021), and we recommend that researchers consider running more web-based experiments, particularly when face-to-face data collection is not possible.

In conclusion, this study investigated the emotionality effect on Korean word recognition by conducting a lexical decision task in laboratory-based and web-based experimental environments. A robust processing advantage for emotional words (both positive and negative) relative to neutral words emerged in both experimental environments. These results suggest that emotional words facilitate lexical processing by attracting attention to the stimuli, which leads to deeper processing.

Declaration of competing interest

The authors declared no conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data availability

Data will be made available on request.

Appendix A

Appendix 1a
Experimental stimuli (Positive/Neutral).

Positive words		Neutral words	
애정	love	신호	signal
감사	gratitude	의무	obligation
애착	attachment	뒷날	future
호감	affection	명함	business card
긍정	positivity	토의	discussion
안도	relief	입사	joining company
존경	respect	이행	performance
기쁨	happiness	감상	thoughts
보람	worthwhile	설득력	persuasion
정감	warmth	억양	intonation
정열	passion	연료	fuel
공감	sympathy	제출	submission
즐거움	joy	메시지	message
쾌감	pleasure	취향	taste
선호	prefer	특질	property
열성	enthusiasm	기력	energy
만족	satisfaction	파동	wave
감탄	admiration	질의	question
감동	touching	서류	document
안심	relaxed	통역	interpretation
환희	delight	심경	mind
교감	communion	은유	metaphor

(*continued on next page*)

Appendix 1a (*continued*)

Positive words		Neutral words	
상쾌감	refreshed	세정력	detergency
자부심	pride	등록금	tuition

Appendix 1b
Experimental stimuli (Negative/Neutral).

Negative words		Neutral words	
조롱	mockery	각색	adaptation
고생	hardship	요청	request
분노	anger	정면	front
불만	dissatisfaction	해석	interpretation
의심	suspicion	금액	payment
비극	tragedy	연습	practice
원한	grudge	소재	material
불행	unhappiness	사연	story
창피	embarrassment	일감	work
절망	despair	연설	speech
질투	jealousy	우상	idol
체념	resignation	납득	accept
신경질	irritation	스케줄	schedule
모욕	insult	회상	reminiscence
비난	criticism	진단	diagnosis
불편	inconvenience	조절	control
원망	resentment	쪽지	note
증오	hatred	시정	rectify
후회	regret	강조	emphasis
우울	depression	하품	yawn
실망	disappointment	추측	speculation
경멸	contempt	수집	collection
고독	loneliness	가르침	teaching
비웃음	ridicule	헛기침	cough

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